The sound of silence: listening to the villagers to learn about orangutans

Orangutans, those shy and gentle primates of Borneo and Sumatra, are iconic of species under threat. Efforts to conserve them have met with little success. But **Kerrie Mengersen** and her colleagues have brought statistics to bear to provide practical guidance towards saving the creature whose name means "old man of the forests".

The forests of Borneo are never silent. Nestled in the Indonesian and Malaysian archipelagos, Borneo is one of the most bio-diverse areas on Earth; it harbours more than 15 000 plant, 420 bird and 221 mammal species, many of them found nowhere else. While most of us struggle to remember even where it is, or know it only as an exotic travel destination, to the many villagers who live on the island this is their home. This shared environment brings challenges for both humans and wildlife, as development meets conservation. Organisations such as The Nature Conservancy (TNC) and many others are working to find more sustainable forms of development and to mitigate changes that threaten many forest species. One of those species is well known to all of us: the orangutan.

Both the Bornean and Sumatran orangutan are threatened with extinction in the wild unless conservation management is improved. Much has been said about this, but rhetoric alone will not save a species. To assess any species' vulnerability to extinction and to inform decisions about managing its conservation, at least three pieces of knowledge are essential: accurate population estimates, assessments of geographic distribution, and a detailed understanding of threats. All three depend on statistical analysis – and the analysis sometimes needs to be complex.

Orangutans are big creatures, and it might be thought that working out how many of them there are would be simple. Unfortunately, it is not. Orangutans, like most species, will not simply stand up and be counted, and their rare, cryptic nature, combined with their shyness and the formidable rainforest, makes direct surveys of their numbers and ranges difficult and generally inaccurate. Orangutans sleep on temporary platforms in trees (called "nests"), and a traditional method of estimating population density is to count nests in a systematic transect survey, and compensate for nest building and decay rates. Mark a line in the forest, move along it, and count how many nests you can see, and how long it takes for them to disappear. Unfortunately, nest decay rates are highly variable in space and time, with nests decaying in as few as 85 days or lasting for over 800 days. Moreover, the time and labour input required properly to conduct nest surveys for orangutans has implications for the scale at which such surveys can be undertaken. In Borneo alone there are some 300

Local people know about orangutans. Statisticians must find ways to access that knowledge

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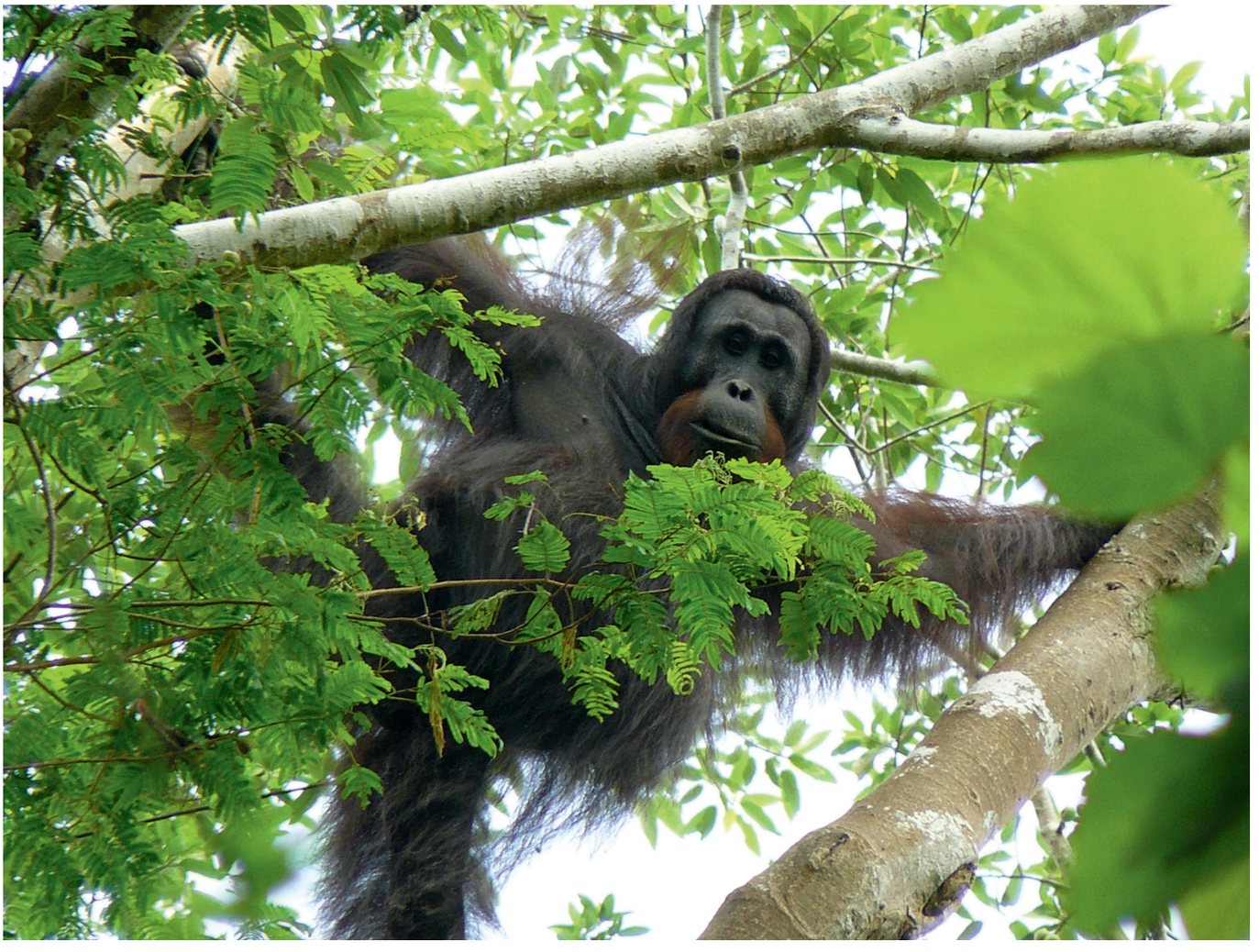

Orangutan

distinct orangutan populations spread over an area that measured 130 919 km^2 in 2004. If we optimistically assume that a particular transect system effectively monitors population fluctuations in some 100 km^2, a complete understanding of orangutan population trends would require more than 1000 transect systems. Each transect requires monthly repeat surveys by two to four survey staff, at a cost of around US$1500/month. An annual survey budget of some $50 million would be required to sustain such an effort. This is about the same as the total annual conservation investment in Indonesia, so is entirely unrealistic. The question is whether there are realistic alternatives.

One such alternative may be aerial surveys. The feasibility of this approach is improving with the availability of helicopters and small planes that are relatively inexpensive to operate, after the initial (high) costs, and that can fly for around six hours. However, although this may make regular monitoring of nest trends more possible, these do not automatically translate into an estimate of population density and do not overcome the problem of accurately inferring density as a function of nest decay.

Here we describe a different approach: asking the villagers. As indicated in the guidelines of the International Union for the Conservation of Nature, the interview method is considered by many as a last resort. This is mainly because of potential biases induced by survey design and inaccuracies in villagers' responses. However, there is a rich wealth of experience and observation held by people who live close to orangutans, and it is up to statisticians to create better methods of accessing it.

The Orangutan survey

The orangutan survey was developed and administered by TNC together with the Indonesian Primatologist Association and 18 local non-government organisations (NGOs). The survey encompassed all regions in Kalimantan, Borneo, with suspected orangutan presence, excluding specific areas (such as national parks) for which data already exist. The survey was based on a questionnaire delivered to ten residents in each of 687 villages, selected from approximately 1500 villages (so we had about 40% sampling); the villages were stratified by high/medium/low threat of land-use change. All high threat villages were included; others were selected randomly.

The survey questionnaire contained 32 questions and 34 optional sub-questions that were initially drafted in English, critically reviewed by orangutan experts, then confirmed in an international workshop in Jakarta. Questions were translated into Indonesian and entered into palmtops, then subjected to a final review during field trials and provincial training workshops. The questionnaire was divided into sections focusing on basic information, on assessment of the reliability of the interviewee, on orangutan presence and abundance, perceived local threats such as plantation and agricultural development and hunting, perceived changes

in orangutan numbers in the past decade, and attitudes to forest use and management. The responses to the questionnaire were entered on the palmtops; GPS cameras integrated into the same palmtops meant that the interview data could be linked to accurate geographic reference points, making mapping and analysis of the data more spatially accurate.

Challenges in statistical analysis

As the "last resort" description implies, there are many challenges in analysing a survey such as this one. We discuss here five of the problems and describe how we attempted to address them.

First, it is important to take account of the study design in the statistical analysis. In this survey, a set of villages was randomly selected in the study area and then villagers were selected within each of these villages. Thus a hierarchical or multilevel model structure was adopted, where the first level corresponded to the villages and the next level corresponded to the villagers (nested within the villages). This model allows participants' responses to be more similar within a village than between villages. Formulating the model in this manner easily allows for extensions; for example, we considered adding another level to the model to allow for differences among the four provinces in the study area.

The statistical model that was employed at the villager level of this hierarchical structure was typically a regression equation. It related a response of interest (such as reported orangutan presence, orangutan killing, or conflict) to a set of potential explanatory factors (such as respondent's sex, age, tribe, religion and knowledge of law). Because the response generally comprised a set of options ("yes/no/don't know", "forest/village/garden/other", etc.), a multinomial logistic regression was generally adopted. *Multinomial* describes the set of multiple, nominal (as opposed to continuous) options, and *logistic* describes the mathematical way of calculating comparisons between the different options – the probability of responding "yes" compared to "no" for presence of an orangutan, the probability of sighting an orangutan in the forest compared to near the village, and so on. Explanatory factors can be similarly added to other levels of the model; for example, at the village level, it is interesting to consider the influence of land use around a village or proximity to forest as predictors of orangutan presence or of conflict between orangutans and people.

The complete model was then cast in a Bayesian framework since this allowed a natural description of the multilevel structure and easily included other study characteristics such as data constraints, missing values, non-standard data distributions and adjustment for potential biases.

Second, the villagers selected for inclusion in the survey had different propensities to observe an orangutan. While some orangutans come close to villages, many remain relatively hidden in the forest. Thus villagers who spend more time in the forest are more likely to have observed orangutans, but had less chance of being included in the survey since they may have been working in the forest or their forest gardens at the time the survey team visited the village. Because the interviewees did not specifically note when especially knowledgeable informants (as identified by the village head) were absent, the potential impact of this source of bias could only be estimated indirectly. We did it in a number of ways: we compared responses between villagers who had been randomly selected and those who had been sought out or volunteered themselves; we calculated the average number of sightings relative to time spent in the forest and compared this with neighbouring villages that were assumed to have similar encounter rates; we undertook a substantial sensitivity assessment to evaluate the potential impact of these issues; and we extended the Bayesian model itself by including additional priors to allow for uncertainty in responses.

Third, reported orangutan sightings may not be independent; many of the villagers may have seen the same orangutan hanging around just outside the village, for example when such an animal raided a fruit tree garden. We assessed this potential bias in a subsample of villages by checking how often interviewees appear to describe the same orangutan; thus, when several interviewees reported having seen the same number of orangutans (e.g. "2") in the same time frame (e.g. last week) it was likely that they were all reporting the same (pair of) animals.

Fourth, we needed to derive appropriate measures of presence (or absence) and abundance based on the questionnaire responses. This presented challenges for a number of reasons. For example, not all respondents could reliably identify an orangutan, from pictures of different mammal species shown as part of the interview; orangutans may have been reported as present by some but not all villagers; respondents within a village may report the same or different orangutans; the propensity of a villager to see an orangutan must be taken into consideration, and so on.

An orangutan nest. Credit: The Nature Conservancy, Indonesia

We addressed this in part by restricting the analyses involving orangutans to those villagers who could reliably identify the species and by creating *reported relative measures*, instead of absolute estimates, of presence and abundance. These relative measures were derived at both the individual and village level. The relative abundance (*RA*) was defined as:

RA = number encountered in the last year/propensity to encounter an orangutan

where "number encountered in the last year" was calculated using sighting frequency ("how often have you seen orangutans in the last year?") among reliable respondents (those who could reliably identify an orangutan) and "propensity to encounter an orangutan" was calculated using a combination of responses to questions involving the number of trips to the forest per year, reason for travel to the forest and the number of nights spent in the forest on each trip. Relative abundance was then categorised into high, medium and low based on quartiles of the observed values (>0.25, 0.25–0.75 and >0.75, respectively). The relative absence/presence ratio (*RAP*) was defined as:

RAP = reported presence/propensity to encounter an orangutan

where "reported presence" was based on reliable respondents who responded positively to both questions, "have you ever seen an orangutan in the vicinity of this village?" and "have you seen an orangutan in the last year?".

Finally, there was a concern that reported threats and challenges to orangutans may have been influenced by the respondents' perceptions

of the goals and eventual application of the survey. For example, sensitive questions about hunting or killing of orangutans may depend on whether the respondents themselves have actually killed an orangutan, their reasons for doing so, and whether they are aware that orangutans are protected under Indonesian law. This was ameliorated to some extent by the design of the questionnaire itself, which was not obviously focused on orangutans; the species was not mentioned in the introduction. Moreover, interviewees were explicitly assured that they were not obliged to answer all of the questions, that there was no sanction for not participating or for any responses, that the survey had nothing to do with law enforcement, and that their responses would be kept confidential and only reported in aggregate form.

Results

The analysis of this survey provided a large suite of interesting results, many of which are still being investigated in order to better understand reasons and implications. Figures 1 and 2 show maps of the reported relative abundance and number of orangutans killed in the past year, based on the survey results. Selected results from the analysis are summarised below.

- Most of the respondents were male, of non-migrant ethnic background, had resided in the present village for at least 20 years, and were almost equally divided between Muslim and Christian.
- Among those respondents who entered the forest, around 25% did so for non-forest-timber products (such as honey), 20% for hunting and 10% for mining.
- Most respondents believed that the forest has cultural significance (83%) and health benefits (90%), but respondents were equally divided in their opinion about the benefit of clearing the forest.
- Over a quarter of respondents did not know whether orangutans were protected by Indonesian law and over half reported that they were not protected by customary law.
- Among respondents who were judged to be able to reliably identify an orangutan (based on photos; see above), almost 20% reported the presence of orangutans around their village in the last year and almost 25% reported seeing an orangutan more than a year ago.
- Almost all of the reliable respondents (92%) reported no conflict with orangutans, as measured by the animals entering their forest gardens.
- Among reliable respondents, 5% ($n = 232$) reported killing an orangutan in the last year, with almost 1000 orangutans reportedly killed by these respondents in this time period. Although almost double this number were reportedly killed by someone in the village, it is difficult to ascertain the amount of duplication of responses to this question. Just over half of the

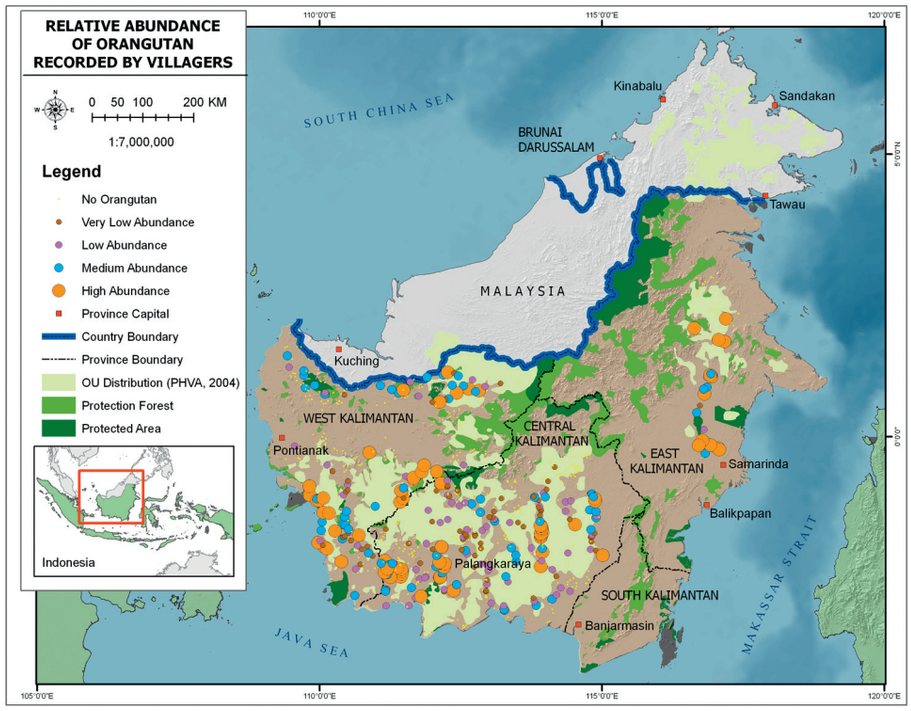

Figure 1. Relative abundance of orangutan recorded by villagers, 2009

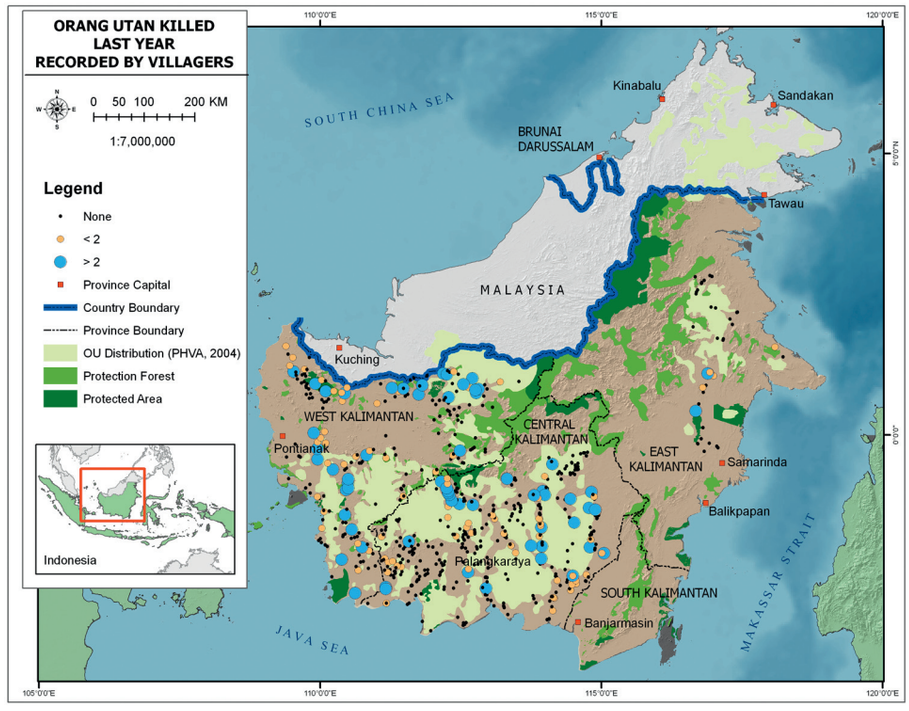

Figure 2. Map of reported number of orangutan killed last year by villagers

killings were reportedly for food, followed by over 10% for each of self-defence, pest of crops and unspecified reasons. Very few reported killing for traditional medicine, to sell orangutan babies for the pet trade, hunting for fun or being paid to kill.

- Perceived trends in orangutan abundance in the past 10 years were significantly influenced by the age, tribe and religion of the respondent, as well as their attitudes to clearing the forest and their experience with orangutan conflict. In contrast, perceived future trends in orangutan numbers were significantly influenced only by tribe, customary prohibitions and conflict.
- There was substantial spatial variation in reported relative absence and presence, relative abundance, threats and attitudes, which was partially influenced by sex, age, ethnic and religious characteristics of the villagers and the demographic and environmental characteristics of the villages.

Concerning orangutans – the practical implications

The results of this survey reveal a number of issues of great interest and concern to conservation organisations and government agencies. Five of these are as follows.

First, based on the relative absence/presence measure, there has been a clear decline in the areas where orangutans were reported to be present compared to range estimates from 2004.

Second, based on the relative abundance measure and perceived past and future trends, there has also been a clear decline in the estimated population abundance of orangutans overall. Interestingly, the survey also identified some hitherto unknown areas in which orangutans were reported to be present. This may indicate a real change in these areas – after all, given that they are closely related to humans, it is not surprising that orangutans might adapt to new environments such as acacia plantations or mangroves if they must and if they can, although their long-term survival in such areas is not yet known. Alternatively, these new areas may simply indicate misclassification or too narrow a sampling frame in previous surveys.

Third, although only a relatively small percentage of villagers reported conflict with orangutans, a surprisingly large number of animals were reportedly killed in the last year. The population impact of these killings is likely to be considerable and is much larger than previously estimated. Based on population viability modelling, annual killing rates in excess of 1% per year are thought to lead to certain local extinction. The present surveys indicate rates of local killing that are much higher than this. Not a single conservation programme is effectively targeting orangutan hunting at present. Perhaps as part of this, there appears to be a role for increased education about protection of orangutans under Indonesian law.

Fourth, although there is apparent overwhelming belief in the cultural and health benefits of the forest, the villagers are divided in their opinion about forest clearing. This has an impact on social, government and industrial endeavours locally, nationally and internationally. In other analyses of the survey not reported here, there has been an alarming decrease in forest cover in Borneo. The major reason for land clearance is currently for oil palm plantations – palm sugar is ubiquitous in many western products. Typically, when the plantations have moved in, the orangutans (and many other forest species) have moved, or been moved, out. Other forest benefits also disappear. On a hopeful note, some progressive developers and conservationists are trying to work out ways in which orangutans and plantations, and even forests, may be able to co-exist – it is early days for these discussions.

Finally, the survey revealed substantial spatial variation in relative presence, relative abundance, threats to orangutans and attitudes to the forest. This will allow for the first time the development of spatially explicit action plans to address issues – plans aimed at specific villages and tailored to those villages. These targeted plans are likely to be less costly than broad-brush national endeavours and more likely to be beneficial in terms of increased interest and support of villagers and sustained changes in practice.

There are many challenges in conducting a village-based survey and making reliable inferences based on the elicited information. However, conservation groups are to be commended for making serious efforts to gather quantitative evidence to inform their endeavours. Through the work of TNC and others, and through the use of powerful statistical modelling, we can learn from the wealth of knowledge vested in these eyes and ears of the forest and learn how to work more effectively towards goals such as conservation of orangutans. These methods are more cost-effective than traditional approaches. They allow for the identification and quantification of threats, and, because of the involvement of large numbers of people, they provide opportunities for information exchange regarding orangutans. The hope is that we can avoid the sound that no one wants to hear in Borneo's forests – the sound of orangutan silence.

Kerrie Mengersen, who designed the statistical framework for this study, and Huanhuan Wu, a statistical analyst, work in Mathematical Sciences, Queensland University of Technology, Australia. Jessie Wells, a quantitative ecologist and conservationist, works in the Ecology Centre, University of Queensland. Damiyanti Buchori is lead scientist in The Nature Conservancy, Indonesia, where she works with Lenny Christy, a GIS specialist. Yokyok Hadiprakarsa, a spatial modelling expert, works for the Orangutan Conservation Services Program, Indonesia. Anton Nurcahyo and Erik Meijaard worked for TNC at the time of the survey, but have now joined the Borneo Orangutan Society and People and Nature Consulting International, respectively. Erik conceptualised and initiated the interview surveys, while Anton took up the considerable challenge of managing the 18 local NGOs that implemented the surveys.

The survey team in transit to a village